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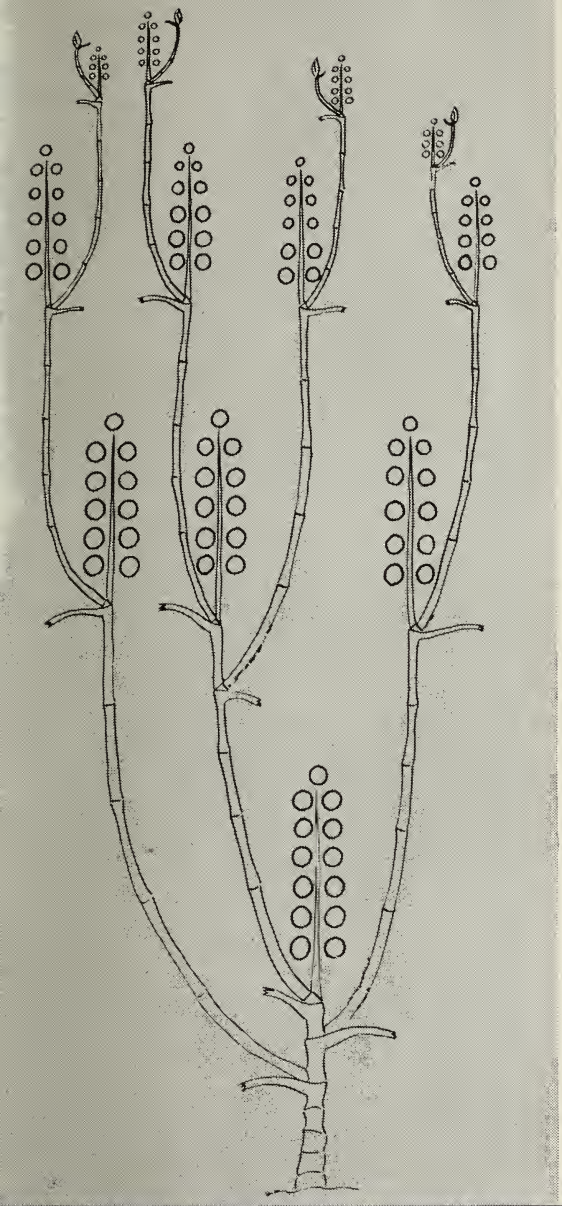

CASTORBEANS

IN CALIFORNIA

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CIRCULAR 468

CASTORBEANS . . . FACTS ABOUT THE CROP

Wide uses of castorbean oil in new manufacturing processes, along with new varieties and harvesting equipment, are making this crop a possible prospect for the farmer, particularly for diverted acres in California. The oil is used in plastics, synthetic clothing and commercial fabrics, nylon bristles, synthetic lubricants, all-purpose greases, hydraulic fluids, artificial leather, pharmaceuticals, soap, printing ink, special low-temperature lubricants and flexible coatings, and fast-drying oils for paints and varnishes.

Plant breeders have reshaped the castorbean plant for machine production and used hybrid vigor to boost yields. Engineers have just developed machines for harvesting the crop.

The U. S. is producing, as of 1957, less than 10 per cent of its present needs. The rest is imported from Brazil, India, Mexico, Italy, and Africa. To meet current needs in this country, some 200,000 to 300,000 acres of castorbeans, yielding 1,000 pounds of beans per acre, would have to be planted (California's average yield was 2,000 pounds per acre in 1957). The nation-wide acreage in 1957 was 15,000 acres, mostly under irrigation, in California, Arizona, and the High Plains area of Texas and New Mexico.

Production costs in California are about the same as for cotton. However, castorbean production is still in a developmental stage as compared with other established field crops.

Castorbeans are well adapted to the Central Valley area in California, especially to the cotton belt. California, Arizona, and Texas may develop into the nation's important production areas. Processing firms, which supply seed and contract for the crops, are located on the west and east coasts.

Your University of California Farm Advisor can supply you with castorbean information for your local area. The processing firms usually have field men to answer questions about growing and harvesting this crop.

Castorbean seeds and leaves, if eaten, are poisonous to man and livestock. Some persons are allergic to castorbeans.

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COSTS . . . AND RETURNS

The investment in a crop of castorbeans is high, as is the investment in any irrigated summer crop, such as cotton. Cost-per-acre estimates in the San Joaquin and lower Sacramento valley regions in 1957 ran to $102. This figure includes $9 for land preparation; $23 for cultural labor and field power; $24 for materials—irrigation, water, seed, fertilizer; $35 for defoliating and harvesting; and $11 for overhead. It does not include a cost for land use.

Before you grow castorbeans, make arrangements for seed and for marketing the crop with a bean processing company. Currently there are two processing firms in California. Your local Farm Advisor will know the location of the closest representatives of these firms.

Castorbeans are bought at a price related to the world market for castor oil and castorbeans. At present there are no acreage controls and no government price-support programs; prices received by U. S. growers have varied in the past few years. In 1956 and 1957 California and Arizona growers received $150 to $160 per ton—7.5 to 8 cents per pound—for their crop delivered to Los Angeles or the San Francisco Bay Area. Beans are bought on a weight rather than an oil-percentage basis.

Under government guarantees in 1951 and 1952 the supported price per pound was 10 cents; in 1953, 9 cents; and in 1954, the last year under a support program, 6 cents. In 1955, the price averaged 5.5 to 6 cents per pound.

WHERE CASTORBEANS GROW

Castorbeans produce highest yields on loam to sandy-loam soils. Generally speaking, if your soil will produce good cotton, it should produce good castors. However, castorbeans are not nearly as tolerant of alkali soil as cotton. Moreover, castorbeans vary in plant height and development, reflecting variation in soil in any given field. On soils very high in nitrogen, the plants tend to develop vegetatively, often becoming tall and difficult to harvest.

The Sacramento and San Joaquin valleys are recommended growing areas for castorbeans. Temperatures there are favorable for the 150- to 180-day growing season necessary for this crop. Also, weather conditions are suitable for planting in late March or April and for harvesting in October or November.

The crop may also be adapted to the Imperial Valley and other similar areas, but successful commercial production there has yet to be demonstrated. If other environmental factors are not just right, temperatures above 105° F may cause various seed-development problems and thus reduce yields.

In coastal areas, cool, humid conditions result in slow plant development, lowering yields; diseases are also more of a problem because of high humidity. Except in limited areas where the soil conditions are satisfactory for natural subirrigation, the crop is not likely to be profitable in California when grown as a dry-land crop.

VARIETIES FOR CALIFORNIA

Two varieties, in Experiment Station tests since 1954, produce the largest yields in California: Pacific Hybrid 6 and Hybrid 415, both developed for mechanized production in California. Under average field conditions, these hybrids can produce 2,500 pounds of seed per acre; yields as high as 3,500 pounds have been obtained. Under test-plot conditions, yields have gone as high as 5,000 pounds per acre. Depending on environment, oil content of these hybrids ranges between 50 and 55 per cent. Another variety, Baker Hybrid 45, tested in California in 1957, will be grown commercially in 1958. Genetically it is about the same as Hybrid 415.

Hybrid 415 and Pacific Hybrid 6 are

similar in plant conformation except that Hybrid 415 flowers one or two stem joints (nodes) higher. Both average about 7½ feet and may range between 3 and 12 feet high.

Seeds of these two varieties are available from California castorbean processing firms. Commercial castorbean growers normally must purchase their seed; like seed produced from hybrid corn, seed produced from hybrid castorbeans should not be planted.

PLANTING THE CROP

Seedbed preparation is important. Tillage implements that help to break up hardpan are recommended. The seedbed may be prepared for flat planting or on beds. A practice popular in cotton seedbed preparation is recommended for castorbeans: irrigation water is run in the furrowed-out land long enough to subirrigate through the ridges or beds. Planters equipped with sweeps will remove enough dry soil from the beds to permit planting the seed 1½ to 3 inches deep in undisturbed moist soil. The seed is thus placed in soil of more uniform moisture than if the seedbed is worked up before planting. Castorbeans germinate slowly, and ample moisture at the planting depth is essential. Also, the first spikes (racemes) of castors grown on beds are higher from the ground level and easier to harvest mechanically.

For prompt germination, plant castors as soon as possible after the soil is warm—usually in late March or early April. Before the seed is planted the soil temperature should be at least 58° F at a depth of 8 inches for 3 days in succession at 8 a.m. The longer the growing season, the higher the yield. May and June plantings are less desirable; do not plant after June 15.

Plant castorbeans in 38-inch rows. Drop single seeds every 6 to 8 inches in the row, using 10 to 12 or more pounds of seed per acre.

Since castorbean seed is easily broken, use special planter boxes, such as the inclined-plate type, designed to agitate the seed as little as possible. Plates should be 5/16 inch thick, with the cells 9/16 inch long and ¼ inch wide. Do not use plates with round holes. Oil from crushed seeds collects dirt, which prevents the seeds from dropping evenly. When this occurs, empty the planting box and wash it with kerosene. Add a handful of white corn meal or some cheap talcum powder to each hopper of seed to help prevent gumming-up of plates. Planting speeds should not be more than 3 miles per hour, since at high speeds the plates cause excessive damage to the seeds. Planters with two hoppers for each row are commerically available. They permit faster planting rates.

Plant seed well into moisture, from 1½ to 3 inches deep, depending on how fast the soil may be expected to dry down to the seed. With early planting, a 1½-inch planting depth is normally sufficient, if soil is well firmed with an open press wheel. But if strong, drying winds are imminent, it is well to pack the planted rows after the surface soil has dried down to about ½ inch.

Castorbeans may take 10 days to as many as 21 days to emerge. If necessary, you may use a light harrow or rotary hoe to break crusts and control weeds before seedlings emerge. When the majority of the young germinating plants have reached the stage where the curved crook (hypocotyl) is near the soil surface, the use of the harrow or rotary hoe is not recommended.

A desired stand is about 100 plants per 100 feet of row, or 13,000 plants per acre. Stands of 75 to 100 seedlings per 100 feet of row are satisfactory. If the seed is carefully planted, thinning is usually unnecessary. Stands in excess of 125 plants per 100 feet of row may require thinning; excessively thick stands may be subject to wind-shatter losses.

FERTILIZING AND IRRIGATING

Fertilizer requirements of castorbeans are similar to those of cotton or sugar beets and may vary considerably with location. Generally, this crop should receive 40 to 100 pounds of nitrogen per acre. Applications at the higher rate may be split during the growing season. Observations to date have revealed no differences in the efficiency of the various forms of nitrogen on castorbeans.

It is possible to overfertilize with nitrogen, producing rank vegetative growth and very little increase in yield. Too little nitrogen results in low yields. Castorbeans following alfalfa or a heavily fertilized row crop probably will not need fertilizer, especially on inherently deep, fertile soils.

Where cereals respond to phosphate, usually castors will also benefit. Apply 40 to 50 pounds of phosphoric acid equivalent at planting time.

Castorbeans are usually furrow-irrigated. Like corn or cotton, castorbeans require frequent irrigation and use about 2½ to 3½ acre-feet of irrigation water during the growing season. *Too much water,* especially before and during the early stages of first raceme development, can result in a wilting of the leaves, just as too little water can. The first irrigation is generally applied at the six- to eight-leaf stage or when the first raceme starts to develop. To avoid overwatering at this time, irrigate every other row. Subsequent irrigations will depend on temperature, the moisture-holding capacity of the soil, and depth of root penetration. Irrigations may have to be spaced as little as 7 days apart to as much as 21 days. With irrigation at 7-day intervals, the plants should be inspected for excessive development of capsule molds.

The plants themselves are the best indicators of irrigation needs. Never allow the leaves to wilt during the morning hours. Castors in such a state of stress can be expected to produce blasted or poorly filled seed and to lose some of

Mature castorbean spike (raceme); seeds are in capsules. Usually there are three, sometimes more, "beans" to a capsule.

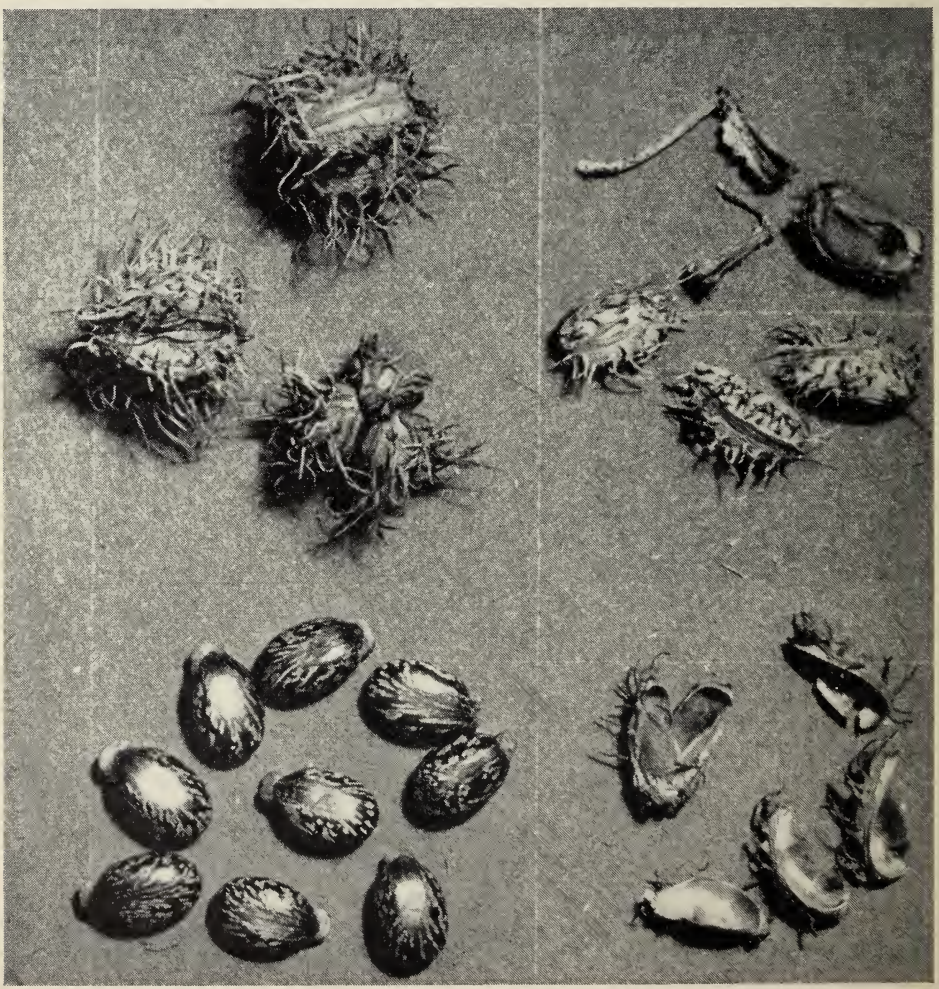
their leaves. The resulting lack of shade may stimulate weed growth. If irrigation water is limited, irrigate each furrow alternately throughout the season.

Castorbeans are also well adapted to subirrigation and develop a deep root system in soils where subirrigation is possible. This permits complete drying of the surface soil, reducing weed problems. As with surface irrigation, overwatering is possible. Therefore, control the water level.

The final irrigation should be three to four weeks before harvest.

WEEDS AND PESTS

Few pests attack castorbeans in California, although weeds can be a problem. Castorbeans, particularly when young, are very poor competitors with weeds. After they have attained some growth, they will shade the area between rows and compete with weed growth. The only effective control so far is cul-



Dry, filled capsules are at the top left. At the top right one of these capsules has been taken apart to show the seed-containing segments (carpels); there are four in this capsule. Clean seeds and remaining hulls are shown on the bottom left and right.

tivation—and only to a shallow depth, for castors have their main lateral roots near the soil surface. Preëmergence cultivation for weeds is possible with a light harrow or rotary hoe. Proper timing of this operation can sometimes save the cost of hand hoeing.

Postemergence cultivation facilities must be ready for prompt use shortly after the crop emerges. The young plants grow so rapidly that the crop can be cultivated for only a limited time.

Though poisonous to man and livestock, the castorbean plant is not toxic to insects. Cutworms and wireworms can reduce stands. Occasional damage has been caused by green stink bugs and the false chinch bug. The yellow-striped armyworm feeds on the foliage, as do webworms, caterpillars, grasshoppers, and leafhoppers. Thrips, spider mites, and leaf miners may also damage the leaves. Lygus bugs, especially the nymphs, have been reported injuring the capsule stems. However, to date none of these except wireworms have been serious enough to require chemical control. Where wireworms are a problem, lindane may need to be added to the seed at planting time. If production expands over a period of years, insect populations may build up to damaging numbers, making control measures necessary. For example, leaf miners have been observed in greater numbers in some of the castor breeding nurseries.

Thus far, diseases that affect castorbeans are a more serious problem in humid and high-rainfall areas than in California. Capsule molds have appeared in the state, but so far they have not been a limiting factor in commerical production.

Seed supplied by commercial firms has usually been treated with a recommended fungicide.

HARVESTING AND HANDLING

Harvesting arrangements should be completed by prospective castor growers before contracting for or planting the crop.

Tractor-mounted harvesters cost about $7,000 per unit. Self-propelled machines cost about $15,000 per unit. A unit is capable of harvesting about 300 to 500 acres per season (if good weather prevails). Current harvesters are designed to work most efficiently at relative humidities of 45 per cent or less. In some districts, custom harvesting can be contracted for. Castorbean processing firms have been helpful in making harvesting arrangements.

Begin harvesting early enough in the fall to complete harvest before the rainy season sets in permanently.

Capsules at harvest time are in all stages of development: mature capsules, green capsules containing filled seed, and green capsules containing unfilled seed. Therefore, you must dry the green capsules and remove the leaves before harvesting the crop. This may be accomplished by frost—28° F for about 4 hours—or by chemical defoliants. Since

REMEMBER . . . CASTORBEANS ARE POISONOUS

Castorbeans—the seeds, leaves, and stems—are poisonous to man and livestock. Ricin and ricinine have been found to be the poisonous constituents. The foliage from young plants about 21 days old is considered to be more poisonous than that from older plants. The plant is generally observed to be unpalatable to livestock; they do not eat it unless forced to by circumstances.

Also, some people are allergic to castorbeans. The seeds contain a powerful allergy-causing substance, separate and distinct from the toxic constituents.

Self-propelled harvester moving through a defoliated castorbean field. This machine is now commercially available. In the foreground are stalks remaining after beans are harvested.

early-fall temperatures in California are not usually low enough for frost, airplane applications of chemical defoliants are made 10 to 15 days before harvest.

A mixture of dinitro general in weed oil is usually successful when maximum daily temperatures are above 85° F. The usual mixture is 1 quart of dinitro general in 10 to 15 gallons of oil per acre where a single application is to be made. If you think two applications will be needed, reduce the dinitro to 1 pint in 10 gallons of oil for the first application; use 1 pint in 7 gallons of oil for the second application. The first application should be made 2 weeks before harvest, the second 1 week before harvest. Since dinitro is less effective at lower temperatures, when daily maximum temperatures drop below 85° F, pentachlorophenol has been used at the rate of ½ to 1½ pounds of actual ingredient per acre.

Harvesters currently in use shake the dry capsules from the standing plants and hull, or shell, the seed. Low-frequency vibrations induced in the branches by knockers that hit the plant near the base, about 8 to 10 inches above the ground, shake the capsules from the plants. A huller-cleaner mounted on the harvester removes the hulls, and clean seed is elevated to a storage bin, also mounted on the harvester. At the edge of the field, the seed is dumped from the bin into a truck and hauled to the crushing plant or receiving point.

Trucks and other equipment used to haul castorbean seed must be cleaned thoroughly before being used for other agricultural products. Since castorbeans are poisonous to humans and livestock, contaminated grain cannot be sold.

The beans store well; whole, cracked, and broken castorbeans that had been in storage for two years have yielded oil that met National Stockpile Specifications for No. 1 castor oil. The oil from cracked and broken seed was slightly lower in quality than that from sound whole seed with respect to free fatty acid.

However, on the basis of equivalent weights, the cracked and broken seed yielded 9 per cent more oil than sound whole seed. This is accounted for by loss of seedcoats, which contain only about 2 per cent oil. (According to the Agricultural Marketing Service of the U. S. Department of Agriculture, freshly hulled seed with no more than 6 per cent moisture and 5 per cent of cracked and broken seed should not deteriorate significantly in storage for at least two years.)

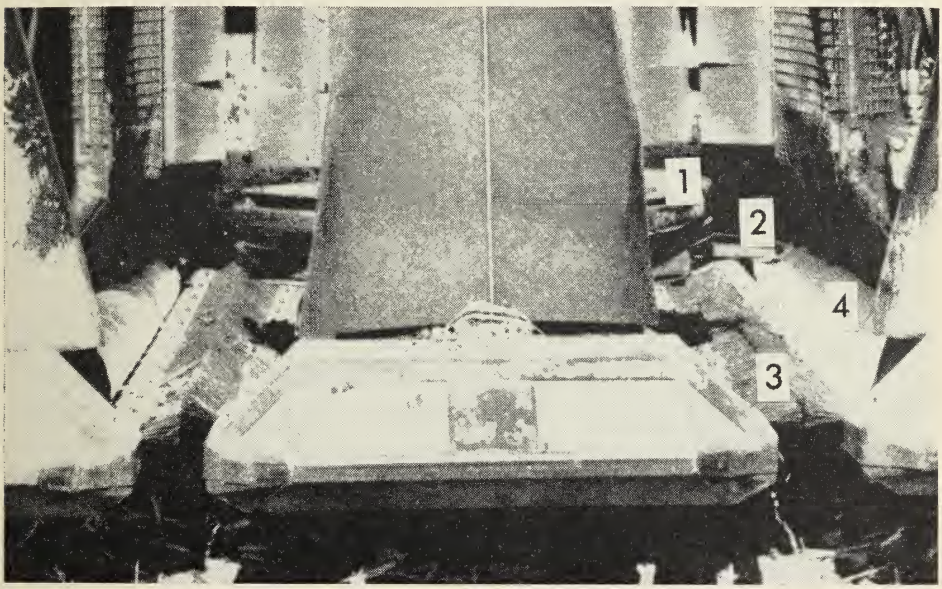
AFTER THE CROP IS HARVESTED

Castorbean crop residues are valuable to the soil. The stalks are easily broken up by mechanical stalk cutters and will disintegrate rapidly when disked into the soil. The hulls have good fertilizer value—equal to or slightly better than ordinary dairy manure—and are scattered over the field during harvest.

Some precautions must be taken with crops that follow castorbeans. Present mechanical harvesters, under normal operating conditions, leave 3 to 10 per cent of the bean crop in the field, the loss increasing with plant height, according to tests by the Department of Agricultural Engineering at Davis. Since unharvested seed may present a volunteer problem in the following crop, the seed should be covered shallowly by disking soon after harvest to permit germination. Irrigation will help bring up the volunteer crop. Castorbean seeds turned a foot under by plowing have been known to emerge late the following summer.

Because of the volunteer problem, it would be unwise to follow castors with a pasture or hay crop. Although castorbeans are unpalatable to livestock, in such a situation it would be difficult for the animals to avoid consuming some of the escape castor plants with their forage, and, if taken in sufficient quantity the young plants are poisonous.

However, castor plants are easily destroyed. Once the plant is cut off below



Close-up view of self-propelled harvester shows harvesting mechanism. A rotary beater (1) with knockers (2) on it hits the plants, shaking the capsules from the plant. The brushes (3), working up and down, flip the capsules into the augers (4), which move them to the huller farther back in the machine.

the first node (usually 2 or more inches above ground level), it will not make regrowth. For this reason, it is a good plan to follow castors with a cultivated row crop, such as grain sorghum, corn, or cotton.

Volunteer castorbeans offer very little competition in cereal grains, which are planted during the cool part of the growing season and shade the ground before the castors emerge. Those that emerge in open areas of a cereal field can be controlled with 2,4-D. Any escapes should be removed; all the grain can be condemned if castorbean seed is present in the threshed sample.

PRODUCTION AND INDUSTRIAL USE

Industrial consumption of castorbeans in the United States has risen sharply in this century. Between 1900 and 1940 it rose from about 13,000 tons to more than 100,000 tons (more than 20 per cent of the world production). During the past 15 years, world production of beans has ranged between 474,000 and 571,000 tons and is currently about 540,000 tons. About 60 per cent is produced in Brazil and India; Africa, Mexico, and Italy are other important producers. According to the U. S. Department of Commerce, the trend of world consumption of castorbeans has been gradually upward since 1945; by 1960, it should be about 565,000 tons of beans (565,000,000 pounds of oil). U. S. consumption of oil has been stable over the past 10 years at about 120,000 tons of beans (120,000,000 pounds of oil). The supply available to this country may be affected by new demands abroad, resulting from new developments in the production of plastics and synthetic fibers. Within the next few years, Europe and South America, where the new industry is being developed, may annually need an additional 37,000 tons of beans (37,000,000 pounds of oil).

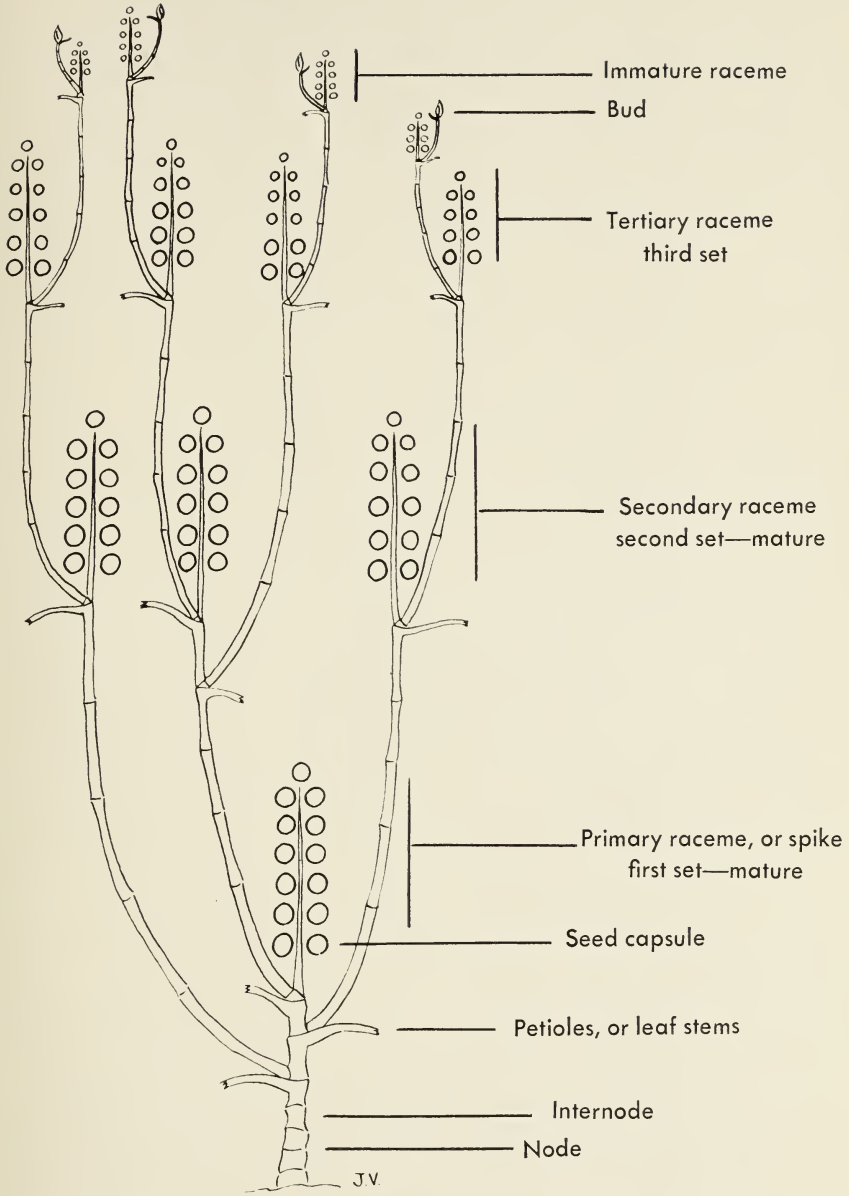
A modern use of castor oil is in the production of sebacic acid, used in manufacturing plasticizers, coating materials, resins, and lubricants for high-speed machines. Castor oil is one of the more versatile of the vegetable oils, capable of several kinds of chemical transformation.

THE PLANT

Although called beans, castors are not legumes. They belong to the Euphorbiaciae, or spurge, family. Many different species have been described, but all are thought to be various types of the one species, *Ricinus communis* L.

A perennial in its native habitat, the castorbean plant is grown as an annual in the temperate areas of the world. A potential tree in the subtropics and tropics, it may attain heights of 30 to 40 feet. The present commerical types may vary in height from 3 to 12 feet, or more, according to environment and variety. Soil conditions may create a great deal of height variation within varieties. Castorbeans have a tap-root system, with prominent lateral roots a few inches below the soil surface.

The large leaves, palmately lobed, are borne more or less alternately on the stems, except for two opposite leaves at the node just above the two cotyledonary leaves, near the base of the plant. The leafstalks (petioles) are usually several times as long as the long axis of the leaves. The main stem ends in a raceme or seed head, known as the first or primary raceme, usually the largest on the plant. The primary raceme of domestic varieties in the United States usually occurs after the sixth to twelfth nodes. In wild types it may occur after 70 or more nodes. After the first raceme appears, stems subsequent to the main one originate at the nodes. The number of stems or branches depends on plant spacing and, in some cases, the variety. Under field conditions, two or three shoots occur almost at the same time but generally in the following order: the first



Defoliated castorbean plant (schematic drawing).

at the node just beneath the first raceme, the second at the second node, and the third at the third node. Each of these shoots, usually after four or five nodes have formed, ends in a raceme, sometimes called the second set. Subsequent shoots arise from the first node just beneath each of the racemes of the second set. Depending on environment, additional shoots may arise at each or any one or more of the second nodes, just as in the case of shoot development below the first raceme. This sequence development of stems and racemes continues as long as the plant remains alive. Thus, the development of racemes along any one axis is sequential, making it possible for a plant to have racemes in all stages of development, from bud stage to complete maturity. In a typical castor plant the racemes usually bear female flowers on the upper 30 to 50 per cent and male flowers on the lower 70 to 50 per cent of the raceme. Current commercial hybrid varieties bear female flowers along the entire raceme. Seed as supplied by the seed companies will contain a mixture to provide the necessary pollinator plants. The number of flowers and the proportion of male to female can vary greatly. The flowers, both male and female, are without petals.

After the pollen is shed, the male flowers dry up and usually drop off. The pollen is carried to the stigmas mainly by wind. After fertilization, the female flowers develop into spiny capsules, though spineless variants are common. At maturity, the hull (pericarp) of the capsule may split violently along the seam (dorsal suture) of each of the three capsule segments (carpels). However, this type of splitting is not characteristic of the commercial varieties now grown under mechanized production.

The seed varies greatly in size, from 450 per pound to more than 5,000, according to variety and environment. The seeds of current commerical varieties range from about 1,400 to 1,800 per pound. Seed may be egg-shaped to oblong to almost round. Seed color may be white, gray, brownish-yellow, brown, black, or various shades of red. The background color is usually modified by one of several mottling patterns. The outer pattern color may be gray or brown to black. The pattern may vary from fine-veined to coarse-veined, or from fine dots to large splotches. The seed coat makes up about 25 per cent of the weight of the seed of current commercial varieties. Depending on variety and environment, the seed contains 40 to 57 per cent oil.

Much of the material in this circular was taken from "Castorbeans: A New Oil Crop for Mechanized Production," by Leroy H. Zimmerman, in Volume 10 of *Advances in Agronomy* (in press).

This circular was prepared with the assistance of Robert C. Bynum, Publications Writer, University of California, Davis.

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

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